Alton Coal Project

Mine Permit Application

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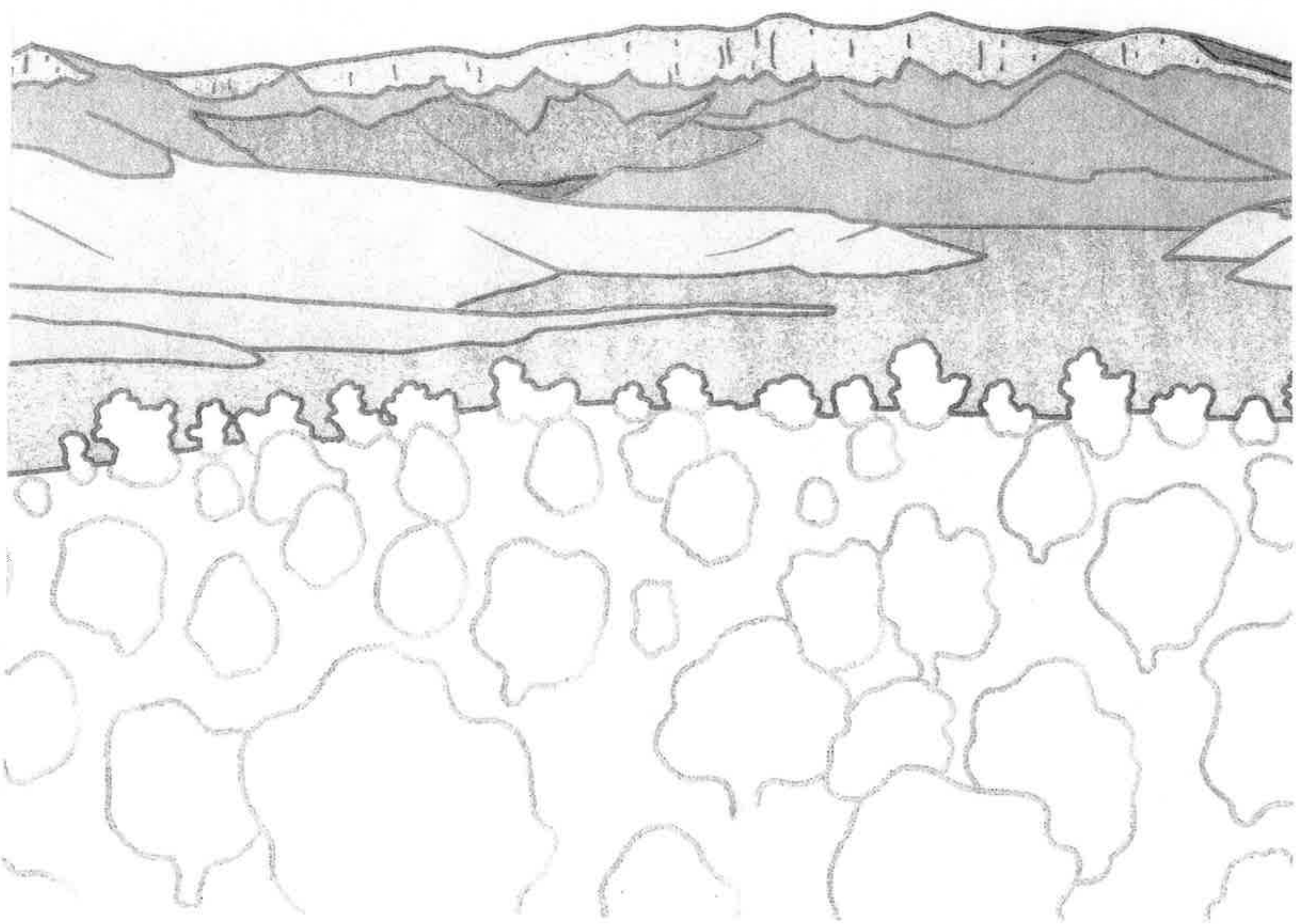

4.5 ALLUVIAL VALLEY FLOOR INVESTIGATIONS

Utah International Inc. (UII) has completed multidisciplinary investigations to demonstrate the presence or absence of alluvial valley floors (AVFs) within and adjacent to the Alton Coal Project Permit Area. The results of these investigations are discussed in detail in this section. Results of previous AVF investigations for the Alton Coal Project were presented in UII's 1982 Alton Mine Permit Application Package (PAP; Appendix G, Alluvial Valley Floor Assessment (UII, 1982)). Based on limited geomorphic, geologic, and hydrologic data, UII's 1982 PAP identified potential AVF areas within Sink Valley, Lower Robinson Creek, Thompson Creek, and Skutumpah Creek. In their Initial Completeness Review (ICR), the Division concurred with UII and a positive determination of the above mentioned AVFs was made (Division, 1985). The Division's ICR also requested that UII determine the exact geographic extent of the four designated AVFs. The Division further identified 29 remaining valleys within and adjacent to the Permit Area as potential AVFs and requested information necessary for a formal AVF determination be provided.

A substantial amount of additional data collection and analysis has been performed subsequent to the 1982 PAP to address the Division's concerns. As a result of the more detailed 1986-1987 investigation, some of the conclusions drawn from this investigation are different from those contained in the 1982 PAP. Supporting documentation for these and other conclusions are provided in Sections 4.5.4 and 4.5.5.

4.5.1 OBJECTIVES AND SCOPE

The Division's regulations require AVF investigations to encompass the Permit Area and adjacent area, the composite of which is called the AVF study area. Because the essential hydrologic functions of an AVF are dependent on the quality and quantity of surface and/or ground water supplied to an AVF, the AVF study area is that composite area defined by both the surface and ground water adjacent areas. The surface water adjacent area includes those drainage basins of Kanab Creek and its tributaries to its confluence with Sink Valley Wash, Skutumpah Creek and its tributaries to its confluence with Johnson Wash, and the headwaters of Adam's Wash, tributary to the Paria River. The ground water adjacent area is that area delimited by the Sevier Fault to the west, the Tropic Shale/Straight Cliffs Sandstone contact to the north, one mile east of the East Panel boundary, and the outcrop of the Carmel Formation to the south.

All of the potential and designated AVFs noted by the Division in their ICR are within the AVF study area with one exception, No. 29-Johnson Canyon and its tributaries: Meadow, Flood, Johnson Lakes, and Dairy Canyon (T42S, R5W). Although not included in the Division's list of 29 potential AVFs, Adams Wash (T40S, R4W, S18 & 19) is included as a potential AVF (No. 30-Adams Wash) within the AVF study area.

The objectives of the AVF investigation were to determine the presence and extent of all potential AVFs within the AVF study area. Two regulatory criteria have been established for identifying AVFs. These criteria are:

1. Presence of unconsolidated stream-laid deposits holding streams; and, where these deposits are present,

2. Sufficient water to support agricultural activities as evidenced by:

   a. the existence or historical use of flood irrigation;

   b. the capability for flood irrigation based on streamflow water yield, soils, water quality, topography and typical regional agricultural practices; or

c. subirrigation derived from the ground water system of the valley floor.

Areas meeting these criteria would establish the presence of an AVF. The current study was designed to provide the Division with sufficient information on the specific AVF criteria to allow a formal regulatory AVF determination for all potentially affected valley bottom areas. Elements of the study incorporated:

- the Division's comments on the 1982 PAP
- any pertinent information obtained from meetings and discussions with Division personnel regarding additional scoping and field work
- the regulatory framework provided in the Division's regulations and federal guidance documents.

4.5.2 REGULATORY CONSIDERATIONS

The investigation of the Alton Coal Project AVF study area was designed and conducted in accordance with the Division's rules and regulations. Much of the clarifying language of the Division's AVF regulatory framework is provided in SMC 700.5, Definitions. These definitions are provided in the following section. In addition to the Division's regulations, technical guidance provided by the OSMRE guidelines (OSMRE, 1983) assisted in directing the investigative effort.

Definitions

Alluvial valley floors, as defined in SMC 700.5, Definitions, means:

> "The unconsolidated stream-laid deposits holding streams with water availability sufficient for subirrigation or flood irrigation agricultural activities but does not include upland areas which are generally overlain by a thin veneer of colluvial deposits composed chiefly of debris from sheet erosion, deposits formed by

unconcentrated runoff or slope wash, together with talus, other mass movement accumulations, and windblown deposits."

For purposes of elucidation, several terms used in the AVF definition are also defined in the Division's regulations (SMC 700.5) as follows:

- "Unconsolidated streamlaid deposits holding streams means, with respect to alluvial valley floors, all floodplains and terraces located in the lower portions of topographic valleys which contain perennial or other streams with channels that are greater than three feet in bankfull width and greater than 0.5 feet in bankfull depth."

- "Subirrigation means, with respect to alluvial valley floors, the supplying of water to plants from underneath or from a semi-saturated or saturated subsurface zone where water is available for use by vegetation.

  Subirrigation may be identified by:

  a. diurnal fluctuation of the water table, due to the difference in nighttime and daytime evapotranspiration rates;

  b. increasing soil moisture from a portion of the root zone down to the saturated zone, due to capillary action;

  c. mottling of the soils in the root zones;

  d. existence of an important part of the root zone within the capillary fringe or water table of an alluvial aquifer; or

  e. an increase in streamflow or a rise in ground water levels, shortly after the first killing frost on the valley floor."

- "Flood irrigation means, with respect to alluvial valley floors, supplying water to plants by natural overflow or the diversion of flows, so that the irrigated surface is largely covered by a sheet of water."

- "Agricultural activities means, with respect to alluvial valley floors, the use of any tract of land for the production of animal or vegetable life, where the use is enhanced or facilitated by subirrigation or flood irrigation associated with alluvial valley floors. These uses include, but are not limited to, the pasturing, grazing, or watering of livestock, and the cropping, cultivation, or harvesting of plants whose production is aided by the availability of water from subirrigation or flood irrigation. Those uses do not include agricultural practices which do not benefit from the availability of water from subirrigation or flood irrigation."

- "Upland areas means, with respect to alluvial valley floors, those geomorphic features located outside the floodplain and terrace complex, such as isolated higher terraces, alluvial fans, pediment surfaces, landslide deposits, and surfaces covered with residuum, mud flows or debris flows, as well as highland areas underlain by bedrock and covered by residual weathered material or debris deposited by sheetwash, rillwash, or windblown material."

Technical Criteria

Additional regulatory guidance has been provided in the form of the OSMRE AVF Identification and Study Guidelines published in draft form in August 1983 (OSMRE, 1983). This publication provides insight to the overall intent of the AVF legislative and regulatory process, upon which specific components of the Division regulatory program were developed. In the guidelines, the OSMRE clarified the statutory definition of an AVF as a result of legislative history, judicial review, and administrative decisions. Accordingly,

> "An alluvial valley floor is defined by the existence of floodplains and terraces underlain by unconsolidated stream-laid deposits, the availability of water by flood irrigation or subirrigation, and the use, or potential use, of that water and land for agricultural purposes." (p. II-11)

These geologic and water availability components of an AVF are further clarified by the OSMRE in their guidelines according to the following criteria which must be met in order for an AVF to be present:

"1. Geologic Criteria:

   a. A topographic valley with a continuous perennial, intermittent, or ephemeral stream channel running through it; and

   b. within that valley, those surface landforms that are either floodplains or terraces if these landforms are underlain by unconsolidated deposits; and

   c. within that valley, those side-slope areas that can reasonably be shown to be underlain by alluvium and which are adjacent to floodplain or terrace landform areas.

2. Water Availability Criteria:

   a. Water is available by surface water irrigation or subirrigation and is being, or has successfully been, used to enhance production of agriculturally useful vegetation; or

   b. Surface water is available and could be used to enhance production of agriculturally useful vegetation." (p. II-11)

In summary, all of the above-listed definitions and criteria provide the basis upon which the Alton Coal Project AVF investigations were conducted and address the key considerations of unconsolidated material type, geomorphic landform expression of the material type, existing and potential water availability, and historic and present land use.

4.5.3 METHODS

4.5.3.1 Geomorphic/Geologic Mapping

The mapping of landforms indicative of unconsolidated stream-laid deposits (USLD) was initially performed by photointerpretive mapping of topographic valley bottom areas. Paired color aerial photographs at an approximate scale of 1:12,000 were viewed stereoscopically and used to delineate extant landforms. The draft AVF guidelines of the OSMRE stress the importance of surficial geomorphic mapping as the primary tool for delineating potential AVFs by noting that:

> "The criteria of an alluvial valley floor place greatest emphasis on identification of alluvial landforms and secondary importance on detailed stratigraphic descriptions of deposits. Only in these valleys where the sloping land adjacent to terraces can be shown to be underlain by the same deposits that underlie the terraces is the knowledge of stratigraphy important in the identification process." (OSMRE, 1983, pp. II-8)

Using the applicable regulatory criteria, landforms of fluvial origin namely, alluvial floodplains and terraces, were differentiated from other landforms such as tributary alluvial fans, valley fans, and colluvial deposits. Where alluvial floodplain and terrace landforms held a continuous stream channel, they were delineated as USLD. Where the latter landforms could reasonably be shown to be underlain by and are adjacent to floodplain or terrace landforms, they were included within those areas delineated as USLD. All other areas were not considered as USLD.

The geomorphic mapping using photointerpretation was field checked, and where necessary, corrections were made directly onto the aerial photographs in the field. Field checking of the landforms and associated deposits was accomplished by observing the overall appearance and expression of the landform and sedimentological characteristics of the material composing the landform if revealed in bankcuts or roadcuts. Photo documentation of typical landforms and sediment exposures was obtained. In addition to the geomorphic mapping, 19 backhoe test pits were excavated and 11 Giddings auger holes were drilled within specified valley bottom areas in order to document and confirm the presence or absence of USLD. Descriptive geologic information was also obtained from the test pits and drill holes, aiding in the characterization and subsequent differentiation of the unconsolidated deposits. As shown on Exhibit 4.5-1, the majority of these pits and holes were located within or proximate to the first five year Permit Term Area.

Sediment and stratigraphic characteristics used in distinguishing the different types of alluvial and colluvial deposits encountered during the investigations included the properties of sedimentary structure, texture, and composition. Sedimentary structure includes stratification, namely, cross-bedding and graded bedding, as well as cut-and-fill features typical of alluvial deposits. Texture includes the properties of sediment size, roundness, and fabric. Composition includes the relative proportions and lithologies of the sediments and aids in differentiation of fluvial or non-fluvial processes responsible for sediment deposition.

Because the geomorphology of the Sink Valley and Lower Robinson Creek area generally lacked landforms characteristic of the valley bottoms of the other drainages in the AVF study area, additional investigations were conducted to determine if, in fact, Sink Valley and/or Lower Robinson Creek met the AVF geologic criteria. To assist in the geomorphic characterization, Mr. Michael D. Harvey, Ph.D. and Mr. Stanley A. Schumm, Ph.D. of Water Engineering Technology, Inc., who are also professors of geomorphology at Colorado State University, closely examined the geomorphology and sedimentology of the Sink Valley/Lower Robinson Creek area using a combination of the following methods:

- o more detailed, site-specific geomorphic mapping of the valley and its margins using aerial photography
- o field examination of surficial deposits exposed in channels, gullies, and roadcuts
- o channel mapping
- o longitudinal and cross valley profile surveys

- grain-size analyses of selected sediments
- analysis of the sedimentary processes likely responsible for the artesian conditions found within areas of Sink Valley
- review of previously collected drilling and test pit information
- historical accounts of Sink Valley and Sink Valley Wash
- a review of the scientific literature addressing depositional processes in semi-arid regions.

Each of the geomorphic/geologic methods previously described, photo interpretation, field mapping, surface and subsurface investigations, and literature review played an integral role in determining the extent of USLD holding a stream within the AVF study area. Only those areas meeting the geologic criteria were subject to additional evaluation with respect to water availability, land use, and other requisite components of an AVF investigation.

4.5.3.2 Water Availability Analysis

In addition to the geomorphic/geologic criterion, the other primary criterion for identifying the presence of AVFs is whether an area has sufficient water available for flood irrigation or subirrigation agricultural activities. The water availability analysis focused on four aspects: natural flood irrigation, current subirrigation, current or historical flood irrigation and capability for artificial flood irrigation. The methods used in addressing these aspects of water availability are discussed in the following sections.

4.5.3.2.1 Natural Flood Irrigation

Natural flood irrigation involves the utilization of naturally-occurring flood flows which overtop existing stream banks and inundate floodplain/terrace surfaces. Areas where natural flood irrigation is used for agricultural activities would meet the water availability criterion. These flood flows should have, at a minimum, a 2 to 3 year recurrence interval for development of flood irrigated agricultural activities. During the course of the field investigations, the potential use of natural flood irrigation within the AVF study area was evaluated by 1) observations and analyses of channel geometry and capacity and of near-channel landforms to qualitatively assess their potential for flood irrigated agricultural activities, and 2) interviews with local landowners regarding existing and past irrigation practices.

4.5.3.2.2 Subirrigation

Two methods were used to determine the presence and extent of subirrigated areas within the valley bottoms: 1) analysis of vegetation composition as it "indicates" or is reflective of subirrigation, and 2) observation and measurement of soil moisture and plant rooting patterns in backhoe test pits.

Vegetation Composition

Vegetation information presented in Section 6.0 was compiled for the purpose of describing baseline conditions and quantitatively characterizing vegetation types in the Permit Area. By necessity, the vegetation types characterized in the vegetation baseline study are broad and relatively few in number. For the purpose of delineating subirrigated areas using vegetation composition, less broadly defined vegetation types are needed in order to discern the effects of highly localized environmental conditions such as subirrigation.

Units consisting of vegetation types suggestive of subirrigation were established and were mapped using both color aerial photography (May 1975) and late season false-color infrared aerial photography (September 1984). The false color IR photography allowed differentiation of plant communities which are artificially irrigated or subirrigated (high reflectance) from those which are experiencing late season moisture deficiency (low reflectance). The mapping was checked in the field in early December 1986.

No plants truly "indicate" or "prove" the existence of subirrigated conditions. Plants which have traditionally been recognized as indicator species (OSMRE, 1983), especially those associated with riparian habitats, have the ability to root deeply and obtain a majority of their water from ground water. Most of these species do not, however, occur exclusively under such conditions. Facultative hydrophytes can tolerate relatively dry soil conditions and are not necessarily indicative of constantly saturated soil. Two species found in the valley bottoms, Baltic rush (*Juncus balticus*) and silver sedge (*Carex praegracilis*), are currently listed by the U.S. Fish and Wildlife Service (1986) as obligate and facultative wetland species, respectively. Where these species occur, they may be considered reliably "indicative" of increased soil moisture conditions, whether the result of subirrigation or surface flow. Where they occur in conjunction with topographic and hydrologic conditions associated with subirrigation, they may be considered "indicators" of subirrigation.

Test Pits

Backhoe test pits were excavated in December 1986 at 19 locations as shown on Exhibit 4.5-1. The pits were excavated to a depth of 12 to 15 feet or to a water table, whichever was shallower. A modified soil profile description was collected at each test pit, including soil horizon depths, texture, and color; size, color, quantity and contrast of any apparent soil mottles; and size and quantity of plant roots. Profile descriptions followed the standards of the National Cooperative Soil Survey (Soil Survey Staff, 1951; Soil Survey Staff, 1981).

At eight of the test pit locations, soil moisture samples were collected at one-foot depth increments, beginning at ground surface. Samples were placed in sample jars, sealed, and transported to the CDM laboratory where percent soil moisture was determined gravimetrically. Percent field moisture was compared to the percent moisture at wilting point as estimated from soil texture (Buckman and Brady, 1969) to assess plant-available water. The profile of plant-available water was then compared to observed rooting depth and frequency, and ground water level. Those locations where a shallow ground water level coincided with "common" or "many" root densities (as described in the soil profile); which supported agriculturally useful vegetation; and that exhibited adequate plant available water were considered apparently subirrigated. Locations not meeting these three criteria, or in which observed root densities were classified as "few", were considered not subirrigated.

4.5.3.2.3 Current Artificial Flood Irrigation

Irrigation practices within the AVF study area were investigated in 1980 and 1986 in conjunction with land use investigations. In addition, 1984 color infrared photographs were utilized as described in the subirrigation section. All irrigated areas identified in the 1986 studies were field checked and delineated on a map. Section 9.2, Land Use, describes methods in greater detail.

In addition to the land use mapping, interviews with several ranchers regarding their agricultural operations were conducted. Several other ranchers were spoken to by phone. Irrigation practices were discussed with each rancher and information on timing and frequency of irrigation and allocation of available irrigation water was obtained. Water availability for additional flood irrigation was discussed with many of the ranchers interviewed. Written summaries of these conversations are presented in Appendix 4.5-F.

4.5.3.2.4 Capability for Artificial Flood Irrigation

An assessment was made of areas underlain by unconsolidated streamlaid deposits not currently irrigated as to their capability for artificial flood irrigation. Initially, information on the regional irrigation practices was collected. This was augmented by information on climate, water quality, water availability and utilization, flood potential, and valley topographic characteristics. Criteria to determine the potential for flood irrigation for those areas currently not irrigated were established using these data. Designation of areas suitable for flood irrigation was based on comparison of these criteria to the characteristics of the valleys in question. The determination of suitability for flood irrigation was based on the following considerations: crops, soils, topography, water availability, water quality, and historic land use. The criteria used for each factor are discussed in the following sections.

Intertwined with each of the physical factors affecting flood irrigation is the consideration of the particular irrigation practices which are typically utilized in the region (Kanab Creek, Sink Valley Wash, Thompson Creek and Skutumpah Creek basins). As noted by OSMRE in the preamble to the final federal AVF rules:

> "The determination of whether an alluvial [valley] floor exists should be based on agricultural practices within the region encompassing the AVF and not upon speculation on what changes in agriculture may take

> place sometime in the future or on agricultural activities that may be accepted in other parts of the country or world." (Fed. Reg. 29804, 1983).

Thus, each of the considerations affecting capability for flood irrigation were evaluated vis-a-vis agricultural practices typically practiced in the region.

Crops

Alfalfa and improved grasses are the only two crops typically grown in the region on flood irrigated pastures (see Section 9.2, Land Use for further discussion). Criteria for acceptable levels of salinity and/or sodicity and trace metals in both soils and water, water requirements for flood irrigation, and the dates for planting and harvesting were based on these crops.

Soils

Important soil characteristics for artificial flood irrigation include available water capacity (AWC), soil infiltration or intake grouping, soil salinity/sodicity, depth to bedrock, and internal drainage. Depth to bedrock and AWC, although important considerations, do not define absolute suitability criteria, but rather are determinants of the amount of water necessary to achieve a particular level of production. Water intake classifications of soils indicate the rate of water movement into the soil. The Order 2 soil survey completed by WESCO in 1981 (Appendix 5.1-1) provided adequate information to determine water intake rates. Because all of the soils of interest in the AVF study are alluvial soils, depth to bedrock was not expected to be limiting. Internal drainage of soil, although important, was not considered for this determination. Soil salinity affects the total production of a given crop and the quality of water which can be used for irrigation. Different crops have different tolerances both to salinity and sodicity. For the purposes of this evaluation, crop salt tolerance was based on Maas (1986), a more current reference than Maas and Hoffman (1977) suggested by the Division's regulations [SMC 785.19(e)(3)(i)(A)].

Topography

Topographic considerations include the depth and width of stream incision and the continuity, size and dissection of the non-irrigated floodplains and terraces. These topographic characteristics affect the economics and practicality of flood irrigating non-irrigated areas. Areas narrower than 500 feet or smaller than 10 acres are not typically developed in the study area for flood irrigation.

The degree of slope and the complexity of slope are also two important considerations in determining suitability for flood irrigation. Most flood irrigation systems require uniform gentle slopes. The SCS recommends that slope not exceed 6 percent for flood irrigation systems, except for contour ditch systems (SCS, 1984). Under some conditions, contour ditch systems may be designed on slopes up to 15 percent.

Water Availability

As noted by the Division in its draft AVF guidance document, water availability is the major limitation to flood irrigating additional areas in Utah (Division, 1987). Flood irrigation systems are designed to provide sufficient water to meet the net irrigation requirements of specific crops. Water requirements are typically determined for given crops on the basis of climatic conditions. Irrigation guides by the SCS (SCS, 1984) were used to determine total and monthly consumptive use requirements for the two dominant crops grown in the study area. Net irrigation requirements (the amount of irrigation water required by the crop for production) are based on crop rooting depths, available soil water capacity, and quantity of water required to replace water lost to transpiration, evaporation, and runoff in the soil at each irrigation. Information from the Order 2 soil survey was used to determine available water capacity of the soils. The quantity of water to be replaced is dependent on water quality (especially salinity) and plant-available soil water capacity. SCS irrigation guide (SCS, 1984) was used to make this determination. Gross irrigation water requirement (the amount of water which must be diverted for delivery to the field) is calculated by dividing the net irrigation requirement by irrigation efficiency, leaching, canal and conveyance losses. Values for these factors were based on those typically found in the Alton area.

In addition to calculating the gross irrigation requirement of the crops typically grown, water potentially available for irrigation was determined at several locations within the AVF study area. Based on the amount of available water at these locations and the gross irrigation requirement for the crops typically grown, the size of an area which could be potentially flood irrigated was calculated.

Potential water availability was calculated using two sets of data: continuous streamflow data collected as part of the baseline surface water monitoring program, and theoretical peak flood flow and volume data calculated by the use of a computer-generated synthetic hydrograph. Continuous streamflow data were collected at stations SW-2, 9, 11, and 12 located on Kanab Creek, Sink Valley Wash, Skutumpah Creek, and Thompson Creek, respectively (see Exhibit 4.5-1). The data were collected as stage height and subsequently translated to flow utilizing an established stage-discharge relationship specific to the site. Section 4.2.3.3.1.3 (Surface Water) describes the methodology by which the stage-discharge relationship for each of the sites was determined. Theoretical peak flow and volume data were generated using the USDA SCS TR-20 computer model. Section 4.2.3.3.2.2 discusses in depth the theoretical and functional aspects of this model and elaborates on how the input parameters of the model were determined. Both the 6-hr and 24-hr mean annual storm event were modeled. The 6-hr event closely mimics short duration (1-12 hr) - high intensity storms typical of the Alton area. Less common, longer duration storms do occasionally occur in the study area. In order to be conservative in the water availability analysis, the 24-hr storm event, which produces a larger flood volume than the 6-hr storm, was also used to calculate potential water availability.

Water Quality

Suitability of water for irrigation is based on soil characteristics, specific crop tolerances, and management. State of Utah agricultural standards (see Exhibit 4.2-95 in Section 4.2) were used as the basis for assessing water quality. Draft OSMRE AVF guidelines (OSMRE, 1983) also present general criteria for irrigation water quality and were considered.

Historic Land Use

The historic capability of an area to support flood irrigated agriculture was considered in assessing suitability of a particular area. If historic land use indicated failure or abandonment of past flood irrigation attempts because of physical/economic characteristics, even for areas otherwise suitable for flood irrigation based on the above criteria, the area was considered unsuitable for flood irrigation. As OSMRE noted in their draft AVF guidelines, "administrative decisions to date show a clear pattern of rejecting capability [for flood irrigation] where abandoned irrigation systems clearly failed due to lack of water or poor quality water in soils". (OSMRE, 1983, p. II-17). Information on abandoned irrigation systems was collected from discussions with local land owners, photointerpretation of 1975 and 1984 aerial photography, and field observations.

4.5.4 RESULTS AND INTERPRETATIONS

4.5.4.1 Geomorphic/Geologic Mapping

The geomorphology of the valley bottoms in the AVF study area is depicted on Exhibit 4.5-1. Appendix A presents geologic logs from the backhoe test pits and Giddings drill holes. Five geomorphic mapping units are found in the AVF study area and each are based primarily on landform as described in the literature and Appendix A, Alluvial Deposits and Geomorphology, of OSMRE's AVF guideline document (OSMRE, 1983). Two additional mapping units were identified: KT - Tropic Shale and Bdrk - Bedrock, undifferentiated. Complete descriptions of the bedrock geology of the Permit Area is found in Section 4.0, Geology. The general geomorphic and sedimentologic characteristics of each mapping unit are described below.

- Alluvial floodplains and terraces (mapping unit Qa) - Alluvial floodplains are evident along the stream reaches of many of the valley bottoms in the AVF study area. These floodplains have been formed primarily by the lateral and vertical accretion of stream-laid deposits. The lateral accretion deposits consist mostly of point bar materials (coarse to fine grained sand and silt) occurring within and along the sides of the channel as the channel migrates laterally. The vertical accretion deposits consist primarily of suspended material (silt and clay) from overbank floodflows. Source material for the silts and clays is predominated by the highly erodible Tropic Shale, which borders the margins of many of the valleys, particularly in the West Panel. Along the channel thalweg, lag deposits composed of cobbles and gravels are common. These coarser clasts consist primarily of quartzites and limestone having originated from the basal conglomerate of the Wasatch Formation or pediment gravels derived from the Wasatch Formation.

Stream channel incision is and has been occurring rapidly throughout the AVF study area due to base level lowering, oversteepened valley or channel reaches, and changes in stream flow characteristics (See Section 4.1, Geomorphic Characterization). As a result, floodflows rarely exceed the bankfull stage, precluding the development of wide, extensive floodplain areas. Within the upper reaches of the main valleys, floodplain width ranges from as wide as 80 feet on Kanab Creek (station SW-1) to as narrow as 10 feet on Sink Valley Wash (station SW-9). Upper Thompson and Skutumpah Creek have floodplains approximately 30 feet wide. Roughly speaking, floodplain widths equal channel widths for most of the drainages. Floodplain development is best exemplified along the lower reach of Kanab Creek immediately above the confluence with Sink Valley Wash. At this location, floodplain width is about 100 feet.

Alluvial terraces formed along the major drainages were identified. These terraces are vestige topographic surfaces of former floodplains and, as such, they are composed of floodplain sediments. Massive bedding of sand, silt and clay was typical for most of the terraces observed in the area. Less common, but present, were structural features such as cross and graded-bedding resulting from moderate to high energy fluvial transport. Within the higher energy deposits, more coarse grained, well-sorted, lenticular deposits of cobbles, gravels and coarse grained sands were noted. Other primary sedimentary structures such as cut-and-fill features were also fairly common.

The terraces of the area are generally paired in that they are found on both sides of the valleys and correspond in elevation. As a result of the recent, rapid incision of many of the valley bottoms, only one set of terraces was observed in all areas mapped as Qa. Within the Alton Amphitheater area, the terrace landform essentially spans the width of the valley floor, up to one-half mile. Further downstream, in the province of the less erodible Dakota Sandstone, the valley narrows to between 200 and 400 feet wide with the terrace landform still spanning the valley floor. Even within some of the narrower valleys such as Mineral Creek (60 to 100 feet wide), terrace development is clearly evident. Within the study area, the alluvial terrace was the most widespread landform meeting the geologic criteria of an AVF. With the exception of Lower Robinson Creek, there are good examples of terrace landforms along all of the major and many of the minor drainages.

- Tributary alluvial fans (mapping unit Qaf) - Tributary alluvial fans were observed at the mouths of the larger drainages tributary to the main valley drainage. The tributary drainages are typified by lessening gradients in a down-valley direction, resulting in the deposition of alluvium in a fan-like form onto a lowland area. Some of the fans, however, have been truncated by stream channel processes which have reworked the fan head where it emerges into the valley bottom. Several good examples of fan truncation are found along the main stem of Kanab Creek (see Exhibit 4.5-1).

The full down-fan profile from apex to terminus is typically concave, whereas the cross fan profile is convex. Channels within the fans are radially distributive, oftentimes with only one channel deeply entrenched. Water flow on the fans is a composite of streamflow (mostly ephemeral), and stream flood, sheet flood and mud flow. Consequently, the presence of lateral and vertical accretion deposits typical of floodplains and terraces is generally lacking. Texture of the fan sediments varies from predominantly coarse material (boulders, cobbles, and gravels) at the fan apex grading to finer material (sands, silts and clays) downslope. Within some fans, sheet and mudflows are evident by the presence of lenses of very poorly sorted material enveloped within a clayey matrix. A good example of a tributary alluvial fan and excellent channel bank exposures of the sediments comprising the fan is found at the mouth of Frankie Hollow (T40S, R6W, S2).

- Valley fan (mapping unit Qafv) - An extensive valley fan was observed in the upper sections of Sink Valley and Lower Robinson Creek during the course of this AVF investigation. This valley fan is the only such landform mapped within the AVF study area. According to Harvey and Schumm (1987; see Appendix 4.5-B), the floors of valleys in the semi-arid regions of the western U.S. can often be comprised of valley fans. Such valley floors are flat-appearing and are irregular in the downstream direction. The irregularities represent convex reaches where sediment is deposited, frequently occurring at or downstream from tributary junctions. As the convexities are formed, the valley floor is steepened locally, and eventually discontinuous gullies form. The discontinuous gullies move sediment down-valley, and the sediment is deposited as smaller fans within the valley where the flow becomes unconfined by the gully walls. Because the processes that operate on the valley fans are similar to those that have been described for the classical alluvial fans in semi-arid areas (Harvey and Schumm, 1987), the general geomorphic and sedimentologic characteristics of tributary alluvial fans previously described generally apply to valley fans. A detailed discussion of the valley fan in upper Sink Valley and Lower Robinson Creek is found in Appendix 4.5-B.

- Valley floor (mapping unit Qav) - A valley floor was observed in the lower section of Sink Valley. Similar to the valley fan, the valley floor landform is unique to Sink Valley within the AVF study area. According to Harvey and Schumm (1987; see Appendix 4.5-B), the valley floor of lower Sink Valley is characterized by an irregular longitudinal profile which is likely due to a multiplicity of reasons, the more significant being (1) tributary contribution of mud flow, debris-flow and sheet-flood sediments from Swapp Hollow, (2) sheet flood and possibly mudflow transported sediments delivered to the lower section of the valley (the valley floor) from the upper section valley fan, (3) sediments derived from discontinuous gullies on the valley fan (4) colluvial sediments transported from the eastern and western valley walls (Tropic shale outcrops) by sheet flow and flows confined within hillside gullies, and (5) trenching of locally oversteepened sections of the valley floor and down-valley distribution of the sediments derived from the trenches.

- Colluvium (mapping unit Qc) - Colluvial deposits are discontinuously present along the margins of the major valleys throughout the AVF study area. In many cases, minor drainages were mapped as colluvium where there was lack of a continuous stream channel or the lack of any indication of the presence of alluvial deposits. Colluvial deposits consist of unsorted debris derived from bedrock, weathered bedrock, soil, and pediment gravels, where present. The deposits, generally found at the base of slopes or within narrow valley bottoms, have been transported downslope chiefly by gravity without the aid of fluvial processes. The colluvial material typically is characterized by angular grain shape, and where transported downslope by sheetwash, is often thinly bedded with variable stratification. Much of the colluvium mapped in the West Panel is massive, composed of clayey material derived from the Tropic Shale.

Presence and Extent of Unconsolidated Stream-Laid Deposits

A sixth mapping unit was USLD holding a stream (shown as a shaded area on Exhibit 4.5-1). As discussed in Section 4.5.3, regulatory and technical criteria were utilized to determine the presence and extent of USLD in the AVF study area. To recapitulate, those areas meeting the geologic criterion for an AVF include all of those valleys holding a continuous stream channel which exhibit floodplain and terrace landform, and those side-slope areas adjacent to the floodplain/terrace complex which can reasonably be shown to be underlain by alluvium. Using these criteria, the lower section of tributary alluvial fans were included within USLD at a point where the alluvial fan debouches onto the floodplain/terrace complex. Similarly, colluvial deposits were also included where these deposits impinged on the floodplain/terrace complex. All other landforms and deposits were not considered USLD.

As previously stated on page 4.5-1, the AVF study area includes only those areas encompassed by the Permit Area and the surface and ground water adjacent areas. These areas define the extent of any potential adverse impacts from mining. Baseline hydrology data (Sections 4.2 and 4.3) and the probable hydrologic consequences (PHC) of mining (Section 4.6) substantiate the boundaries of these adjacent areas. As a result, drainage No. 26, Johnson Canyon and its tributaries Meadow, Flood Johnson Lakes and

Dairy Canyon is removed from further consideration as an AVF because it lies beyond the limits of the surface and ground water adjacent areas and will not be affected by mining.

Within the AVF study area, there were a number of areas which were not adjacent to floodplain or terrace landforms and which had only colluvially-derived material present. These areas, removed from further consideration as AVFs, are:

No. 12 - Areas Surrounding Bald Knoll
No. 13 - Unnamed drainage
No. 14 - Unnamed drainage
No. 23 - Fourmile Hollow
No. 24 - Broad Hollow
No. 25 - Dry Wash

As depicted on Exhibit 4.5-1, additional valley bottom areas, including areas previously identified as AVFs, were mapped as colluvium, tributary alluvial fan, valley fan, or valley floor. Where these areas were adjacent to floodplain or terrace landforms holding a continuous stream channel and could reasonably be inferred to be underlain by alluvium, they were included within the floodplain/terrace landform to which they were adjacent. For example, drainage No. 3, Lick Creek, was mapped as a tributary alluvial fan. Only that area of the fan which debouches onto Skutumpah Creek was considered as USLD and subsequentially, as part of the potential Skutumpah Creek AVF. Other areas where the geomorphic criteria were not met were removed from further consideration as AVFs. These areas are as follows:

Lower Robinson Creek
Sink Valley
No. 3 - lower Lick Creek
No. 4 - 2 Unnamed tributaries to Skutumpah Creek
No. 5 - Unnamed tributary to Skutumpah Creek

No. 6 – Unnamed tributary to Skutumpah Creek
No. 15A – Sink Valley Wash (T39S, R5W, S31 and 32 only)
No. 18 – lower Swapp Hollow
No. 19 – Lower Robinson Creek
No. 21 – Alton Amphitheater Area (Kanab Creek and tributaries)
No. 27 – Coal Hollow
No. 28 – Frankie Hollow

Within the remaining valley bottom areas, floodplain and terrace landforms were evident and are illustrated on Exhibit 4.5-1. Those areas mapped as floodplains and terraces which held a continuous stream channel and those areas adjacent to floodplains or terraces which could reasonably be shown to be underlain by alluvium were delineated to be USLD. Thus, the remaining areas listed in the Division's ICR meet the geologic criteria of an AVF and are as follows:

Thompson Creek
Skutumpah Creek
No. 1 – Mill Creek
No. 2 – lower Mineral Creek
No. 7 – Unnamed tributary to Skutumpah Creek
No. 8 – Tenny Creek
No. 9 – Unnamed tributaries to Thompson Creek
No. 10 – Bald Knoll Hollow and associated tributaries
No. 11 – Fuller Cove
No. 15B – Sink Valley Wash (T40S, R5W, S5, 6, 7, 8, & 18)
No. 16 – Broad Hollow
No. 17 – Unnamed tributary to Sink Valley Wash
No. 20 – Kanab Creek
No. 21 – Alton Amphitheater Area (Kanab Creek and tributaries)
No. 22 – Unnamed tributary to Kanab Creek
No. 29 – Oak Canyon
No. 30 – Adams Wash

These seventeen potential AVFs meeting the geomorphic/geologic criterion were subjected to additional investigation with regards to water availability and land use.

4.5.4.2 Water Availability Analysis

4.5.4.2.1 Natural Flood Irrigation

Natural flood irrigation is currently not occurring on areas underlain by USLD within the AVF study area. Several reasons prevent the use of the natural flood irrigation. The primary reason is depth of incision of the stream channels in the area. As discussed in Section 4.5.4.1, all of the major drainages in the AVF study area are deeply and broadly incised, with depth of incision ranging generally from 7 to 30 feet or more (see Exhibit 4.5-9 for depths). Incision depth on the lower reaches of Kanab Creek near its confluence with Sink Valley Wash range up to 80 feet. The size of the drainage channel provides containment of storm-generated flood flow events, precluding the overtopping of channel banks. Another reason for lack of natural flood irrigation in the area is the unpredictable nature of storm-generated flood events and the concomitant undependable irrigation water supply. Further discussion of storm-related flow is found in the surface water hydrology section, 4.2.3. Finally, although the four major drainages (Kanab Creek, Sink Valley Wash, Thompson Creek and Skutumpah Creek) have developed a narrow modern floodplain immediately adjacent to the stream channel which is subject to annual flooding, development of agricultural activities on the floodplain of these drainages is precluded by the instability of floodplain deposits, its narrow width, and its inaccessibility.

4.5.4.2.2 Subirrigation

Areas underlain by USLD within the AVF study area which are apparently subirrigated are shown on Exhibit 4.5-2. Within the Permit Term Area and adjacent area, no such areas were identified. In future permit terms, if mining may potentially affect areas that are apparently subirrigated, detailed hydrologic studies assessing the essential hydrologic functions wi actual subirrigation and potential mining impacts.

Two types of areas apparently subirrigated were identified within areas underlain by USLD. The two types are 1) apparently subirrigated (native vegetation present) and 2) apparently subirrigated (native vegetation removed during agricultural improvement). The first type was delineated on the basis of vegetation composition, topographic position and corroborative test pit data. The basis for delineating the second type was the same as the first with exception of vegetation composition. Each type is discussed in the following sections. Information collected from the test pits is presented in Exhibit 4.5-3. Soil profile descriptions and laboratory analyses of soil moisture samples are presented in Appendices 4.5-C and 4.5-D, respectively. Agricultural utility of the two types is discussed further under Section 4.5.4.2.3, Current and Historic Artificial Flood Irrigation.

Apparently Subirrigated (Native Vegetation Present)

The vegetation mapping unit identified in areas underlain by USLD that suggests or "indicates" the presence of subirrigation is Sedge-Rush Meadow. This area along upper Kanab Creek has conspicuous development of silver sedge and Baltic rush. These hydrophytes are present despite an absence of obvious sources of surface moisture, suggesting that their moisture requirements are being met by subsurface supplies. A test pit located in this area (KC-TP1) corroborated the apparently subirrigated nature of this type. In this test pit, plant-available moisture extended upward from an apparent water table through the soil to a level well within the zone of

EXHIBIT 4.5-3

INFORMATION FROM BACKHOE TEST PIT DATA FOR SELECTED AREAS UNDERLAIN BY USLD

Representative Test Pit No.	Hydrophytic Species Occurrence	Vegetation Present	Starting Depth of Continuous Mottling (in.)	Depth of Abundant Roots (in.)[a]	Maximum Root Depth (in.)	Depth to to Ground Water (in.)	Depth Below Which Plant-Available Water Continuously Occurs (in.)	Plant Root Zone Extending into Plant-Available Water Zone[b]
KC-TP1	Yes	Sedge-Rush	58	40	156	156	Surface	Yes
KC-TP2	No	Dry Sagebrush	108	18	108	>120	>120	No
KC-TP3	No	Dry Sagebrush	72	4	132	>132	ND[c]	ND
KC-TP5	No	Pinyon-Juniper Woodland	>144	60	108	>144	ND	ND
KC-TP6	No	Dry Sagebrush	>208	34	120	>208	ND	ND
BN-TP1	No	Dry Sagebrush	>168	52	168	>168	ND	ND
BN-TP2	No	Dry Sagebrush	>156	12	132	>156	ND	ND
TC-TP1	No	Agricultural Hayland	>168	24	156	>168	ND	ND
TC-TP2	No	Dry Sagebrush	>150	84	108	>150	>120	No
SC-TP1	No	Dry Sagebrush	>156	25	132	>156	120	No
SC-TP2	No	Pinyon-Juniper Woodland	>168	52	93	>168	ND	ND

[a] Depth above which root abundance was rated as "common" or greater.

[b] Plant roots extending into plant available water continuous with ground water indicates subirrigation.

[c] ND - Not determined.

abundant plant roots (see Exhibit 4.5-4). This pattern suggests that plants of the site having substantial access to ground water are subirrigated.

<u>Apparently Subirrigated (Native Vegetation Removed During Agricultural Improvement)</u>

Some areas lacking plant species indicative of subirrigation were mapped as subirrigated based on color IR photo interpretation and topographic position. These areas are shown on Exhibit 4.5-2 as Apparently Subirrigated (Native Vegetation Removed During Agricultural Improvement). The native vegetation in these areas has been removed and replaced with alfalfa or introduced forage grasses. The plant species present are often able to benefit from subirrigation but are capable of surviving without it. Test pit TC-TP1 was located in such an area. Test pit moisture profiles <u>not</u> indicating subirrigated conditions are KC-TP2, SC-TP1 and TC-TP2 (see Exhibits 4.5-5, 6, and 7, respectively).

4.5.4.2.3 Current and Historic Artificial Flood Irrigation

Irrigation is limited to land along four major drainages: Kanab Creek, Sink Valley Wash, Thompson Creek, and Skutumpah Creek. Areas currently or historically irrigated are shown on Exhibit 4.5-2. Irrigation practices between drainages do not vary significantly. Typically, water is diverted by small dams into unlined irrigation ditches and conveyed to small reservoirs or directly to pastures. Irrigation is used primarily for the production of alfalfa or alfalfa/grass hay, or for improved grass pasture. A few small areas of small grains, such as oats or wheat, are also irrigated. Section 9.2, Land Use, discusses current land uses in the area in greater detail. Although agricultural operations do differ within the area, irrigation typically begins in April, with the grass pastures

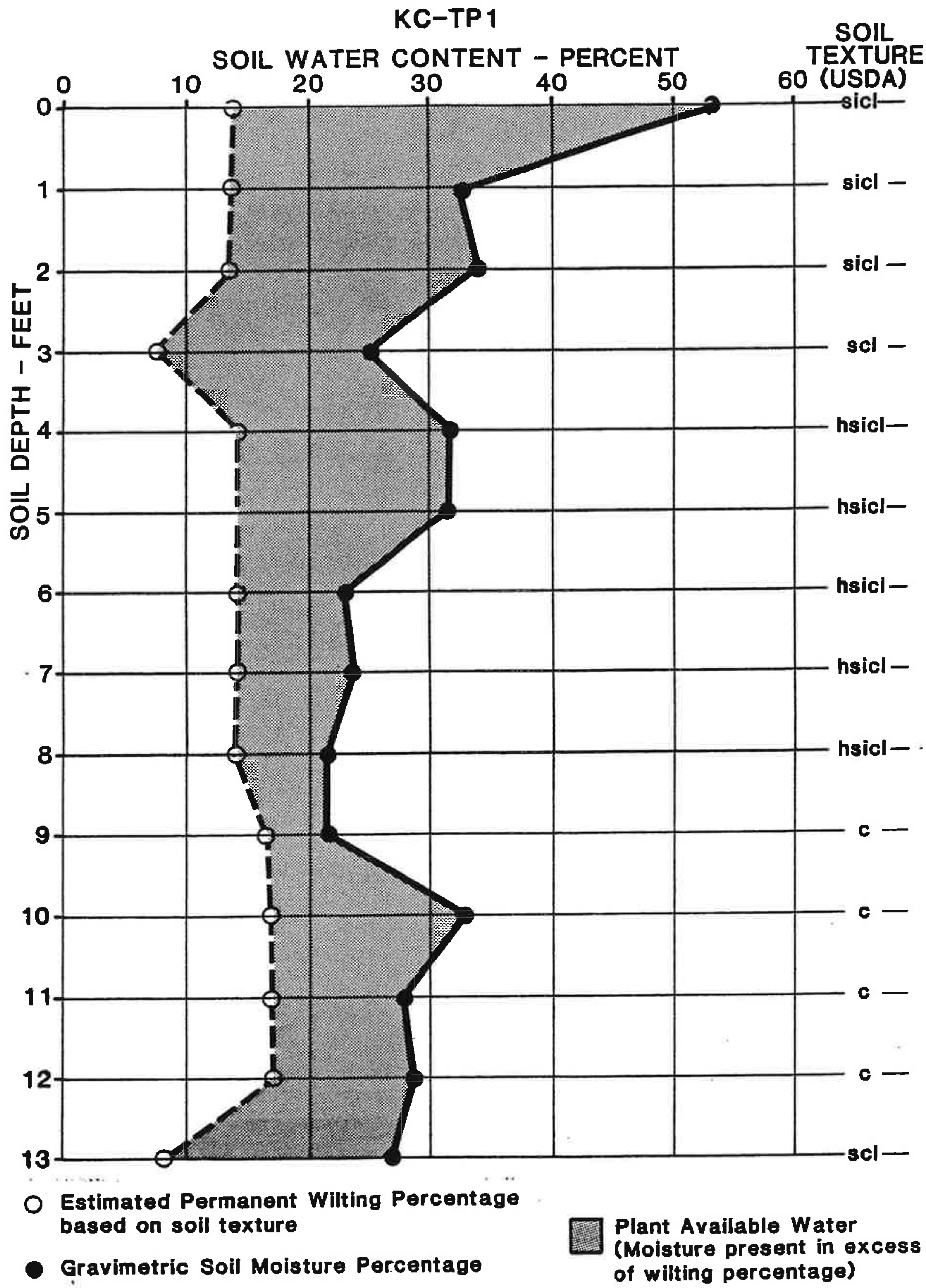

Exhibit 4.5-4 Soil Moisture Profile Backhoe Test Pit KC-TP1

CDM
environmental engineers, scientists, planners, & management consultants

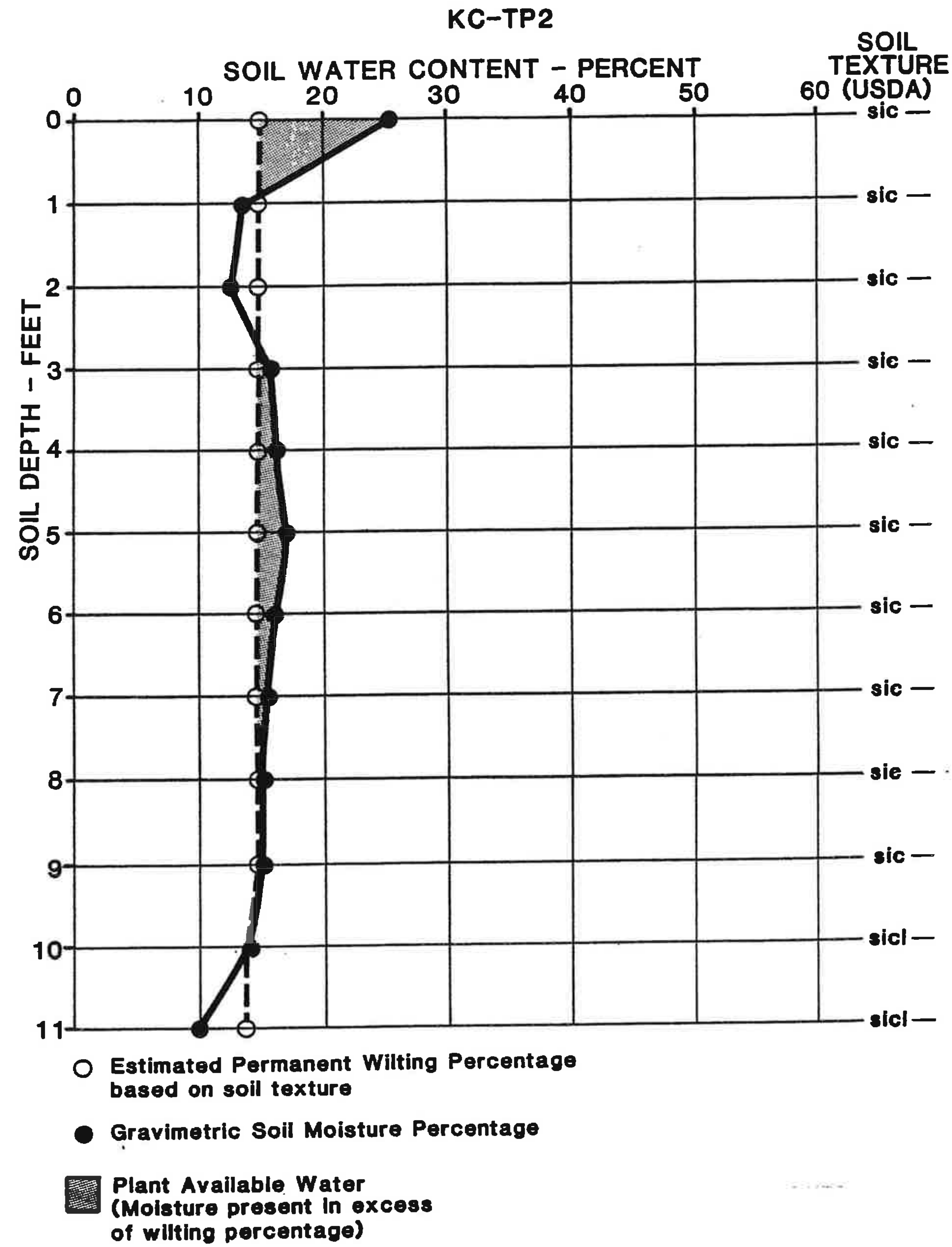

Exhibit 4.5-5 Soil Moisture Profile Backhoe Test Pit KC-TP2

CDM
environmental engineers, scientists, planners, & management consultants

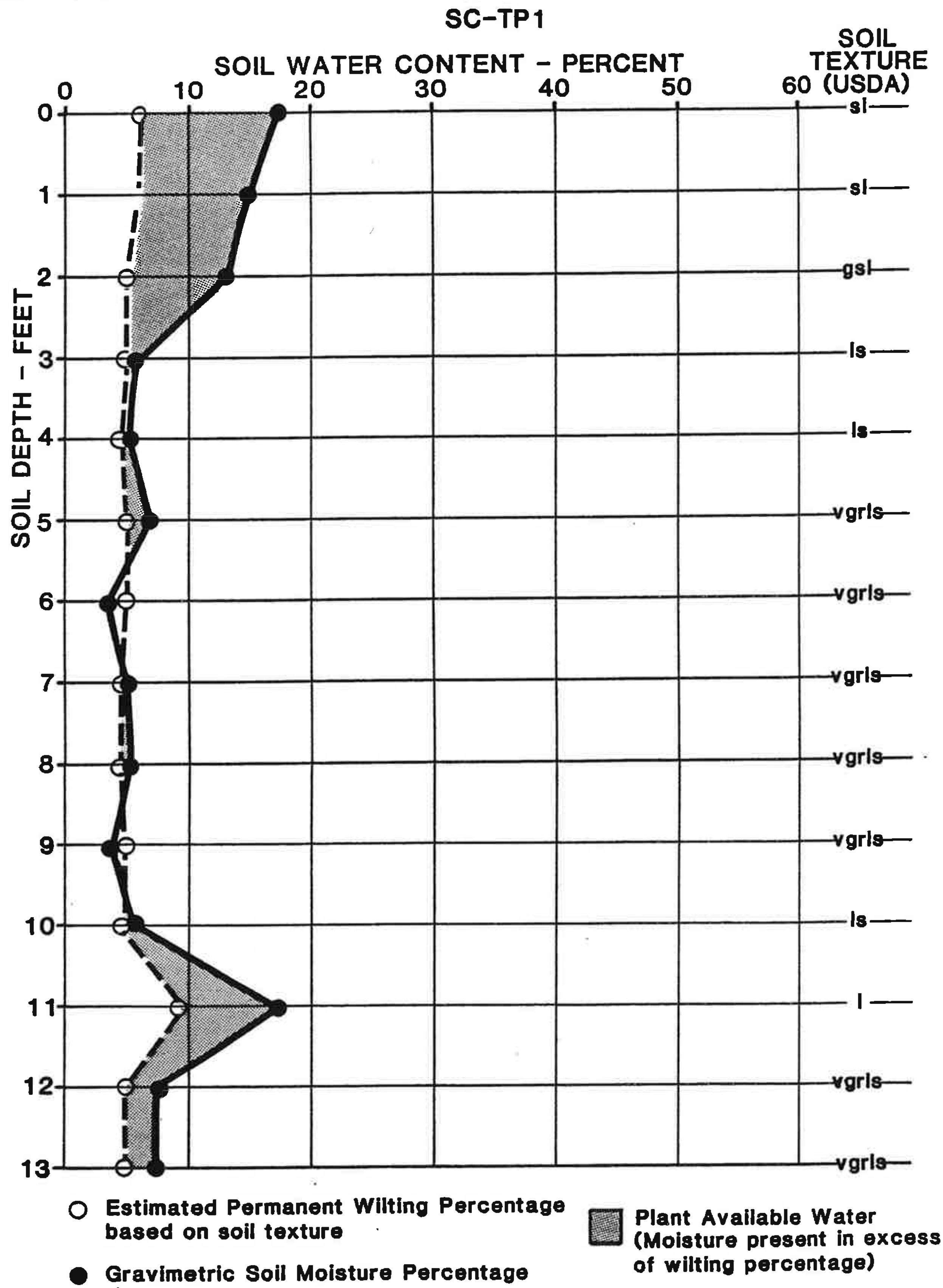

Exhibit 4.5-6 Soil Moisture Profile Backhoe Test Pit SC-TP1

CDM
environmental engineers, scientists, planners, & management consultants

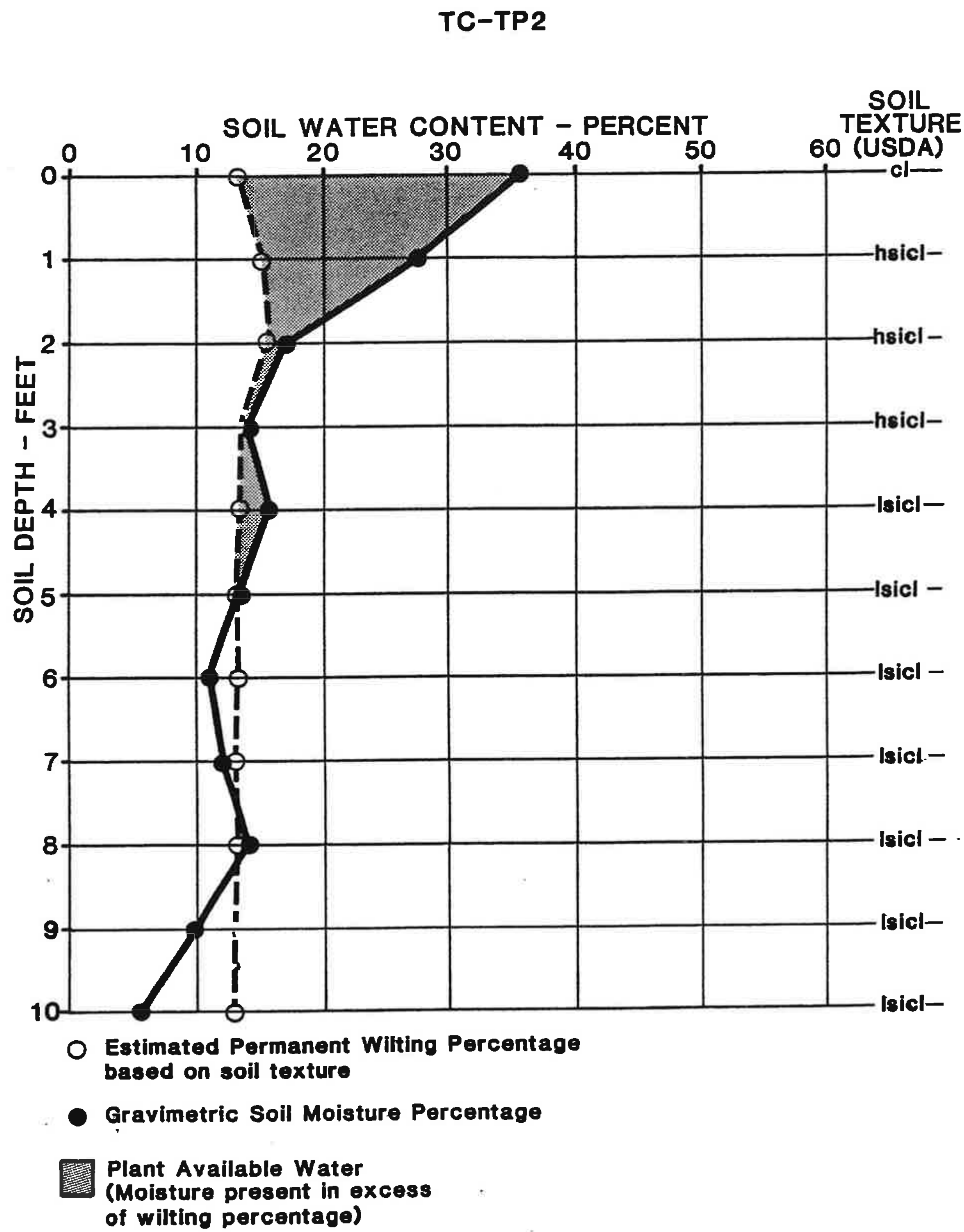

Exhibit 4.5-7 Soil Moisture Profile Backhoe Test Pit TC-TP2

CDM
environmental engineers, scientists, planners, & management consultants

receiving the first supply of water. After the grass pastures have been irrigated, hay pastures are irrigated. Depending on the supply of water, hay pastures are usually irrigated between once every 10 days to 16 days. After a second cutting of pastures, water is again used to irrigate grass pastures. Because water available for irrigation is generally in short supply, some pastures are only irrigated twice a year, once in the spring and once in the fall.

As shown on Exhibit 4.5-2, there is little correlation between areas underlain by USLD and current or historic irrigation using surface water. Acreage of lands presently or historically flood irrigated underlain by USLD is somewhat greater than areas presently or historically irrigated not underlain by USLD. In other words, meeting the geomorphic criteria for AVFs - USLD holding streams - has had little influence in the study area on the decision to irrigate a particular pasture. Other factors, such as patterns of land ownership, proximity to and availability of water, soils and topography, have played a greater role in determining the distribution of irrigated pastures in the study area.

Kanab Creek

The largest area currently irrigated is in the Alton Amphitheater area using water diverted out of Kanab Creek several miles upstream from the Alton Coal Project Permit Area. As discussed in the hydrology section, the surface water rights in the Alton area are controlled by the Alton Farmers Association. There are five major ranchers who use water in the Alton area: the Heaton Brothers (the largest operation in the area), L. Heaton, F. Heaton, D. Roundy, and O. Palmer. Two other ranchers, S. Lamb and F. Lamb, also use water diverted out of Kanab Creek south of the town of Alton. Mr. S. Lamb's operation is located at the confluence of Lower

Robinson Creek and Kanab Creek. Mr. F. Lamb's irrigated pasture is just north of the confluence of Coal Hollow and Kanab Creek.

It is not certain if the apparent subirrigation in upper Kanab Creek is enhancing production of agriculturally useful vegetation and is facilitating development of agricultural activities. This uncertainty stems from the irrigation practices of the Alton ranchers who use the apparently subirrigated areas. As shown on Exhibit 4.5-2, some areas which appear subirrigated are also flood irrigated, suggesting the need for the additional flood irrigation to enhance agricultural production. A desire for increased vegetation production may not be the only reason for flood irrigating such areas. Other factors, such as land ownership patterns or proximity to water diversion, probably affect the use of water for flood irrigation on areas apparenty subirrigated.

Ranchers in the Alton Amphitheater area are increasingly switching from flood irrigation to sprinkler irrigation. Much of the land which is currently sprinkler irrigated was either flood irrigated or not irrigated in 1981 (WESCO, 1981). Most of the irrigated soils in the Kanab Creek drainage have clayey surface textures. On these soils, sprinkler irrigation allows for more frequent application of smaller amounts of water, thus reducing surface runoff and erosion. Sprinkler irrigation also reduces the amount of water lost in conveyance. Nearly all of the sprinkler irrigation is gravity fed. Kanab Creek water is diverted into small reservoirs (see Exhibit 9.2-2, Land Use Map for the location of these reservoirs), and the differences in elevation between reservoirs and fields provides sufficient hydraulic head for the sprinkler systems. Most storage reservoirs are small, with the largest having about a 15 acre-foot capacity.

S. Lamb flood irrigates several pastures along Kanab Creek near its confluence with Lower Robinson Creek. F. Lamb irrigates one pasture just north of the confluence of Coal Hollow and Kanab Creek. Water is diverted out of Kanab Creek and is carried by ditch to three reservoirs. The Lamb ditch is shown on Exhibit 4.2-11 in the surface water hydrology section. Some small amount of water is also diverted out of Lower Robinson Creek into one of the reservoirs, although this water does not contribute a significant amount of water to either operation. Because both operations lack a large enough elevation difference between the water supply and the irrigated fields, gravity-fed sprinkler irrigation is precluded.

Sink Valley and Sink Valley Wash

Irrigation in these areas is limited to Sink Valley north of County Road 136. None of these areas are underlain by USLD. Some private land exists on USLD below where the wash crosses the county road, but has not been developed for irrigation. Several ranchers have operations in Sink Valley: R. Pugh, E. Sorensen and O. Johnson, who leases the Swapp Ranch property. Mr. Pugh does not systematically irrigate any areas. Although he has water rights to and is diverting some water out of Lower Robinson Creek, the water is conveyed by a very leaky pipe to a small reservoir in upper Sink Valley. The water used for livestock water or is run out onto a small, unimproved pasture below the reservoir.

In 1986, Mr. Johnson constructed a small reservoir to hold water from a nearby spring. The water is planned for flood irrigating a small hay pasture that was seeded in late 1986.

In the past, Mr. Sorensen has had the greatest irrigated pasture acreage in Sink Valley, all of which have been used for hayland. Based on a 1986 site visit and conversations with Mr. Sorensen, he no longer flood irrigates any pastures with surface water. A small area, however, is still flood irrigated with water from an artesian well. The 1984 color IR photos show that some of Mr. Sorensen's pastures were irrigated at that time; the 1980 land use map (WESCO, 1981) also has several pastures mapped as flood irrigated. Mr. Sorensen still diverts water out of Swapp Hollow into a small reservoir where it is used for livestock watering. Ditches leading from this reservoir to the hay pastures still exist.

Thompson and Skutumpah Creeks

All irrigated pastures along Thompson and Skutumpah Creeks are at least a mile from the Permit Area boundary. These pastures generally overlie USLD. Two ranchers irrigate land along these creeks. D. Bunting has several pastures irrigated with water diverted out of Thompson Creek. J. Johnson irrigates land along both creeks with water from either Thompson Creek or Skutumpah Creek. Johnson and Bunting split Thompson Creek water on a weekly basis.

Irrigation practices are similar to those used by ranchers along Kanab Creek. Surface water is diverted out of the creek and carried by unlined ditches to the fields. Irrigation usually starts in April with spring snowmelt. In contrast to Kanab Creek ranchers, Mr. Bunting and Mr. Johnson supplement surface water flow with alluvial ground water, usually starting sometime in July. Locations of these wells are shown on Exhibit 4.2-1 in the ground water section.

Mr. Bunting, in previous years, sprinkler irrigated a pasture in SE1/4, NW1/4, S31, T40S, R4 1/2W with his alluvial well water (Mr. Bunting estimated water yield at 100 to 150 gpm). In 1986 and 1987, the pasture was not irrigated and any ground water pumped was diverted into the ditch carrying Thompson Creek surface water. Because surface water flow out of Thompson Creek decreases substantially in mid-summer, Mr. Bunting reduces the amount of land he irrigates after that time.

Mr. Johnson uses water for irrigation primarily from two wells, estimated by him as yielding 850 gpm and 650 gpm. Alluvial well water is generally used exclusively for irrigating all his pastures starting sometime in July.

4.5.4.2.4 Capability for Artificial Flood Irrigation

As mentioned in Section 4.5.3.2.4, the discussion of the capability of additional areas to be artificially flood irrigated will focus on physical conditions pertinent to irrigation suitability, namely: topography, soils, water quality, historic land use, and water availability.

Topography

Topographic considerations prevent development of flood irrigated agricultural activities on many areas underlain by unconsolidated stream-laid deposits. The primary topographic constraint on the smaller drainages, such as Mineral Creek or Tenny Creek, is the depth of incision and very narrow width of the floodplain/terrace complex. Eleven drainages within the AVF study area have floodplains or terraces (including the incised channel) which are less than 500 feet wide. The narrowest, Mineral Creek, has an area underlain by USLD of less than 100 feet wide. Many of these drainages have small tributaries which are incised. As a result, these drainages have only small continguous areas suitable for flood irrigation. Based on these topographic constraints, the following drainages were eliminated from further AVF consideration:

No. 1 - Mill Creek
No. 2 - lower Mineral Creek
No. 7 - Unnamed tributary to Skutumpah Creek
No. 8 - Tenny Creek
No. 9 - Unnamed tributaries to Thompson Creek
No. 11 - Fuller Cove

No. 16 - Broad Hollow
No. 17 - Unnamed tributary to Sink Valley Wash
No. 22 - Unnamed tributary to Kanab Creek
No. 29 - Oak Canyon
No. 30 - Adams Wash.

Another topographic constraint to development of flood irrigated agricultural activities, especially on the larger drainages such as Kanab or Thompson, is terrace instability caused by stream channel meandering. In conjunction with the incision of the tributary fans, stream meandering limits the extent of contiguous areas suitable for development. The largest contiguous area (about 150 acres) of USLD not currently flood irrigated or subirrigated is along Kanab Creek north of its confluence with Sink Valley Wash in T39S, R5W, S23 and 26. Most contiguous areas along Kanab, Thompson and Skutumpah Creeks and Sink Valley Wash are considerably smaller, ranging in size between 20 and 40 acres.

The slope-related topographic considerations are steepness of slope and smoothness of slope. All areas underlain by unconsolidated streamlaid deposits have slopes less than 15 percent, the upper slope limit for irrigation suitability. Some areas which are potentially flood irrigable have uneven slopes. Although overall irrigation efficiency might increase with land leveling, land leveling is not typical in the study area.

Of the remaining 17 potential AVFs underlain by USLD, eleven were eliminated because of topographic constraints. The six remaining potential AVFs were evaluated in terms of soils, water quality and water availability with regards to potential flood irrigation.

Soils

Based on an assessment of the soils in the valley bottoms investigated, there are no soils-related limitations to development of flood irrigation.

With the exception of a few small areas, all soils have low levels of salinity and sodicity, parameters usually affecting irrigation suitability of western soils. Some soils, particularly those located in the West Panel, have clayey surface textures which reduce water intake rates and decrease overall irrigation efficiency. Investigations to assess limitations due to poor soil drainage were not conducted. Based on the soil types and typical irrigations practices, internal soil drainage is assumed to be adequate for flood irrigation. Further discussion of the characteristics and geographic extent of the soils is provided in Section 5.1, Soils.

Water Quality

Water quality standards for agricultural uses are listed in Exhibit 4.2-95 of Section 4.2.3.4.3. These standards have been established by the State of Utah Department of Health for all waters of the State (Utah, 1984). As part of the surface water baseline monitoring program, water quality parameter exceedences at each sampling station (crest gage stations) were compiled; the exceedences are listed in Exhibit 4.2-96. As evident from analysis of the exceedence table, the only parameter to exceed its standard is TDS. The 1200 mg/l limit for TDS concentration was exceeded at stations SW-2 (lower Kanab Creek) SW-9 (Sink Valley Wash), and SW-15 (Mineral Creek) for the summer, fall and winter samplings of 1986. Stations SW-1 (upper Kanab Creek), SW-5 (Lower Robinson Creek), SW-12 (lower Thompson Creek), and SW-16 (upper Thompson Creek) have also occasionally shown TDS concentrations higher than the suggested standard. From Table B-5 of OSMRE's guidelines (OSMRE, 1983), irrigation water with a TDS content of 1000-2000 mg/l may have adverse effects on many crops and requires careful management practices. Although relatively high TDS concentrations (1000-2000 mg/l range) suggest less than optimal crop yields by both State of Utah standards and OSMRE guidelines, it has been demonstrated in the study area that ambient TDS concentrations do not preclude irrigation of those valley floor areas where stream-diverted irrigation is presently being practiced (see Exhibit 4.5-2). As a result, water quality for all potentially flood irrigated areas is assumed to be generally adequate.

Historic Land Use

Several areas in the study area are no longer flood irrigated but have been sometime in the recent past. As discussed in Section 4.5.4.2.3, E. Sorensen flood irrigated several pastures in Sink Valley prior to 1986. Most of these pastures are also appeared to be subirrigated. The reason for cessation of irrigation was not determined. Although not shown on Exhibit 4.5-1, P. Swapp once irrigated several pastures in Sink Valley, according to his son-in-law, O. Johnson. The exact locations of these pastures are not known, though abandoned irrigation structures were observed (see Exhibit 4.5B-1). L. Heaton reported a former flood irrigated pasture on the east side of Kanab Creek. Irrigation ditches are clearly visible on the 1975 aerial photographs. The 1980 WESCO land use study (WESCO, 1982) identified one pasture historically flood irrigated in upper Kanab Creek. This area is outside the AVF study area and is not shown on Exhibit 4.5-1.

Water Availability

Since July 1986, continuous flow data have been collected at the four monitoring stations listed on Exhibit 4.5-8 and depicted on Exhibit 4.5-1. These stations, located downstream from the proposed mining, display intermittent or perennial flow for their period of record. In 1986 and 1987, flow from Kanab, Thompson and Skutumpah Creeks was being utilized for irrigation; diversion of water for irrigation from Sink Valley Wash is not practiced. In order to estimate how much acreage could theoretically be

EXHIBIT 4.5-8

SUMMARY OF CONTINUOUS FLOW AND MEAN ANNUAL THEORETICAL PEAK FLOWS AND VOLUMES FOR SURFACE WATER AVAILABILITY ANALYSIS LOCATIONS

Continuous Monitoring Station[a]	Mean Flow (cfs)	Drainage Area (sq mi)
SW-2	0.48	24.0
SW-9	0.22	5.5
SW-11	0.33	4.7
SW-12	0.83	13.8

Crest Gage Station[a]	6-Hour		24-Hour		Drainage Area (sq mi)
	Peak Flow (cfs)	Volume (ac-ft)	Peak Flow (cfs)	Volume (ac-ft)	
SW-1	1,120	480	1,120	640	17.9
SW-2	2,270	1,010	2,350	1,350	37.0
SW-3	1,170	570	1,200	760	21.8
SW-4	580	130	580	180	4.2
SW-5	1,010	320	1,010	500	10.4
SW-7	310	30	310	40	1.0
SW-8	330	40	330	60	1.4
SW-9	810	240	810	310	7.7
SW-10	230	40	230	60	1.4
SW-11	540	120	540	240	11.7
SW-12	1,080	357	1,070	530	12.7
SW-14	320	70	320	100	4.8
SW-15	160	40	160	60	2.3
SW-16	480	130	480	190	9.3
SW-17	160	60	160	100	5.6
Additional Water Availability Analysis Locations[a]					
Bald	195	56	195	86	4.9
Frankie	460	58	60	77	1.8
Kanab	1,598	635	1,599	856	24.7

[a] Refer to Exhibit 4.5-1 for locations.

irrigated using recorded mean flows tabulated in Exhibit 4.5-8, a detailed analysis of irrigation requirements for the two crops typically grown in the area, alfalfa and improved grass, was made (see Appendix 4.5-E). The gross irrigation requirements for each of these crops after considerations of losses due to leaching needs, conveyance efficiency, field canal efficiency, application efficiency and management control was determined. After calculating the gross irrigation requirements, an irrigable area in acres was calculated according to the equation:

$$A = (I_s)(Q)(T_a)/F_g$$

Where

A = irrigable area in acres

I_s = irrigation season in days/year

Q = mean flow in cfs

T_a = time of application in hours/day (assume 24 hour availability)

F_g = gross application in ac-ft/ac/year

For alfalfa and pasture grass, the irrigation season is typically 175 and 205 days respectively; the gross application for the two crops was estimated to be 6.6 and 6.5 ac-ft/ac/year, respectively. All calculations for determining gross irrigation requirements of alfalfa and pasture grass are presented in Appendix 4.5-E. The calculated irrigable acreages as determined at each of the continuous monitoring sites are tabulated in Exhibit 4.5-9. Mean flow for the period of record (July 1986 - February 1987) was used because of the unavailability of mean monthly flow data for the entire growing season.

EXHIBIT 4.5-9
POTENTIALLY IRRIGABLE ACREAGES FOR ALFALFA AND IMPROVED GRASS

Continuous Monitoring Station[a]	Drainage	Depth of Incision[b] (ft)	Potentially Irrigable Acreage[c]	
			Alfalfa	Improved Grass
SW-2	Kanab Creek	25	14	22
SW-9	Sink Valley Wash	23	7	10
SW-11	Skutumpah Creek	13	10	15
SW-12	Thompson Creek	16	25	38

Crest Gage Station[a]	Drainage	Depth of Incision[b] (ft)	Potentially Irrigable Acreage[c]	
			Alfalfa	Improved Grass
SW-1	Kanab Creek	26	97	99
SW-2	Kanab Creek	25	205	208
SW-3	Kanab Creek	10-16	116	117
SW-5	L. Robinson Creek	7-11	76	77
SW-7	Sink Valley Trib	7	6	6
SW-9	Sink Valley Wash	22	47	48
SW-10	Sink Valley Trib	7-11	9	9
SW-11	Skutumpah Creek	13	37	37
SW-12	Thompson Creek	16	81	82
SW-16	Thompson Creek	23	29	29
SW-17	Bald Knoll Hollow	28	15	15
Additional Water Availability Analysis Locations[a]				
Bald	Bald Knoll Hollow		13	13
Frankie	Frankie Hollow		12	12
Kanab	Kanab Creek		130	132

[a] Refer to Exhibit 4.5-1 for locations.
[b] From station cross sections (see Section 4.2, Surface Water Hydrology). Available only for those locations with monitoring stations.
[c] Based on the length of the irrigation season; mean flow for the period of record; gross irrigation requirement of the crop to be grown; and the amount of time that flow is available during the day.
[d] Based on storage of the theoretical mean annual 24-hr flood flow volume, and the gross irrigation requirement of the crop to be grown.

Conversations with several ranchers in the study area revealed that surface water flows decrease significantly from mid to late June to early August. Flows generally increase slightly in August and September in response to convective thunderstorms. Mean flow based on the period of record tend to overestimate the amount of water available for flood irrigation relative to expected lower mean monthly flow in critical months of the growing season. Using the mean flow for each of the four sites, potentially irrigable acres of improved grass for Kanab Creek (station SW-2), Sink Valley Wash (station SW-9), Skutumpah Creek (station SW-11) and Thompson Creek (stations SW-12) are calculated to be 22, 10, 15, and 38 acres, respectively. Realistically, the number of potentially irrigable acres would be lower using expected lower mean monthly flow.

Based on conversations with four ranchers that irrigate using water out of Kanab Creek (R. Heaton, F. Heaton, L. Heaton, S. Lamb; see Appendix 4.5-F), there is apparently not sufficient water available to irrigate any additional acres along Kanab Creek. As discussed previously under current artificial irrigation, there are some pastures, both alfalfa and grass, that are irrigated only twice yearly. If additional water was available in the Alton Amphitheater area, it would first be used to irrigate these existing irrigated pastures prior to irrigating pastures which are presently not irrigated.

Ranchers utilizing Thompson Creek and Skutumpah Creek surface water also report reduced summer flows. After mid-July, dependable surface flow from Skutumpah Creek is sufficiently reduced to require use of alluvial ground water to maintain irrigation. Late summer storms, however, do provide high intensity surface flow of short duration. Flows on Thompson Creek are similarly reduced, with D. Bunting reporting a reduction of irrigated area after mid-July. Despite apparent water availability for flood irrigation development using available mean flow data, the lack of sensitivity of mean flow to mid-summer low flow and conversations with local ranchers indicate that the lack of available water prevents any additional flood irrigation development along Kanab Creek, Thompson Creek, Skutumpah Creek and Sink Valley Wash.

Utilization of theoretical mean annual flood flow volumes is another means by which to determine availability of water for flood irrigated. Assuming that a structure was built that could capture, store, and release on an as-needed basis the flow generated from the mean annual flood event, the acreages tabulated in Exhibit 4.5-9 could potentially be irrigated given their gross irrigation requirements previously mentioned. Minor drainages such as Broad Hollow, Elbo Spring (tributary to Sink Valley Wash), Bald Knoll Hollow and Mill Creek have, individually, less than 20 potentially irrigable acres. The smaller drainages such as Oak Canyon, Adams Wash and No Name (lower tributary to Skutumpah Creek) have even less irrigable acreage. Many of the smaller drainages with low flood flows are precluded from flood irrigation development because of topographic characteristics, as discussed previously. Development of an entire irrigation system for such a small amount of acreage would not be practical nor typical of the region. Considering these results, it is clear that only the major drainages in the AVF study area could potentially be used for artificial flood irrigation.

Assuming only one flood irrigation retention structure on each of the major drainages in order to maximize the collection of flow from all available drainage area, stations SW-2 on Kanab Creek, SW-9 on Sink Valley Wash, SW-11 on Skutumpah Creek and SW-12 on Thompson Creek could each theoretically store enough water to irrigate 200, 50, 40 and 80 acres, respectively. Water storage at each of these sites would have to have capacities of 1,350, 310, 240, and 530 ac-ft, respectively. The phrase, "theoretically store", should be emphasized in light of the fact that the largest structure used for irrigation in the Alton area is less than 15 ac-ft; most of the other reservoirs in the area are substantially smaller. In summary, the use of large retention structures for irrigation in the study area is not practiced, likely because of the high sediment load carried by the streams during major storm events and because of the prohibitive cost of dam construction relative to the return on the capital investment.

4.5.5 CONCLUSIONS

In order to affirmatively demonstrate the presence or absence of AVFs within or adjacent to the Alton Coal Project Permit Area (also referred to as the AVF study area), multidisciplinary investigations were performed. These investigations were conducted in accordance with the Division's rules and regulations. In the absence of state guidelines, the draft AVF Identification and Study Guidelines published by the OSMRE (1983) were utilized. Additionally, the Division's comments on the 1982 PAP and other pertinent information obtained from state regulatory personnel were incorporated into the AVF investigative approach.

The geologic and water availability criteria required for an AVF determination provided the basis upon which the investigation was conducted. These criteria also determined the methods by which data were obtained and analyzed. The results of the investigation are summarized in Exhibit 4.5-10. This table details the findings with regard to the AVF criteria evaluated for each potential AVF. The table readily indicates those valley bottoms within the AVF study area which are, or are not, probable AVFs while also indicating those criteria responsible for the AVF determination.

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The results of detailed investigations clearly indicate that, of the four previously identified AVFs, only Thompson and Skutumpah Creeks meet the applicable AVF geologic and water availability criteria. Portions of these drainages are considered as probable AVFs. Because of water availability constraints due to typically low mid-summer flow as evidenced by agricultural practices typical for the area, the geographic extent of probable AVF on these two drainages is limited solely to those areas which hold a stream, are underlain by USLD, and are currently flood or sprinkler irrigated with surface water. By definition of the water availability criterion, those areas currently flood or sprinkler irrigated with ground water do not qualify as AVFs in the absence of sufficient surface water for flood irrigation.

The two other previously identified AVFs, Lower Robinson Creek and Sink Valley, were both determined not to be AVFs because they did not meet the geomorphic/geologic critera. Specifically, Sink Valley does not hold a continuous stream. Further, neither Sink Valley nor Lower Robinson Creek exhibit landforms characteristic of USLD, i.e., floodplains and terraces, and are not adjacent to such landforms. The valley bottoms of these two drainages contain valley fan, tributary alluvial fan and valley floor landforms with associated debris-flow, sheet flood, mudflow, and to a lesser extent, streamflow deposits.

Two additional potential AVFs occurring in the AVF study area, No. 20-Kanab Creek and No. 21-Alton Amphitheater Area (Kanab Creek and tributaries), meet the geomorphic and water availability criteria and are probable AVFs. Again, because of the water availability constraints previously mentioned for Thompson and Skutumpah Creeks, the geographic extent of the AVF on these drainages is limited solely to those areas which hold a stream, are underlain by USLD, and are subirrigated or currently flood or sprinkler irrigated with surface water.

All of the remaining potential AVFs in the AVF study area are not AVFs because they either were not underlain by USLD or they were not currently supporting flood irrigated or subirrigated agricultural activities and they were not capable of supporting flood irrigated agricultural activities. Primary limitations to development of flood irrigated agricultural activities on non-irrigated areas included insufficient availability of water for flood irrigation and topographic considerations.

In summary, only those valley bottom areas within the AVF study areas which hold a continuous stream, are underlain by unconsolidated streamlaid deposits, and presently support subirrigated or flood or sprinkler irrigated agricultural activities qualify as probable AVFs.

4.5.6 REFERENCES

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No.	Previously identified AVFs	Location	Within Permit Area and Adjacent Area (AVF Study Area)	Alluvial Valley Floor Crite[ria] — Geologic — Unconsolidated stream-laid deposits holding a stream[a]	Wate[r] — Currently subirrigated or flood irrigated[b]	Suitable Topography
	Lower Robinson Creek	See Exhibit 4.5-1[d]	Yes	No		
	Sink Valley	See Exhibit 4.5-1[d]	Yes	No		
	Thompson Creek	See Exhibit 4.5-1[d]	Yes	Yes	Yes	Yes
	Skutumpah Creek	See Exhibit 4.5-1[d]	Yes	Yes	Yes	Yes
No.	**Remaining Potential AVFs[f]**					
1	Mill Creek	T40S, R4½W, S5 & 8	Yes	Yes	No	No
2	lower Mineral Creek	T40S, R4½W, S9	Yes	Yes	No	No
3	lower Lick Creek	T40S, R4½W, S16	Yes	No		
4	2 Unnamed tributaries to Skutumpah Creek	T40S, R4½W, S21	Yes	No		
5	Unnamed tributary to Skutumpah Creek	T40S, R4½W, S17 & 20	Yes	No		
6	Unnamed tributary to Skutumpah Creek	T40S, R4½W, S20 & 29	Yes	No		
7	Unnamed tributary to Skutumpah Creek	T40S, R4½W, S18, 19, 30, 31, & 32	Yes	Yes	No	No
8	Tenny Creek	T40S, R4½W, S8	Yes	Yes	No	No
9	Unnamed tributaries to Thompson Creek	T40S, R4½W, S19 & 30	Yes	Yes	No	No
10	Bald Knoll Hollow and associated tributaries	T40S, R5W, S14	Yes	Yes	No	Yes
11	Fuller Cove	T40S, R5W, S10, 11, & 15	Yes	Yes	No	No
12	Areas surrounding Bald Knoll	T40S, R5W, S9, 10, 15 16 & 21	Yes	No		
13	Unnamed drainage	T40S, R5W, S26	Yes	No		
14	Unnamed drainage	T40S, R5W, S25	Yes	No		
15A	Sink Valley Wash	T39S, R5W, S31 & 32	Yes	No		
15B	Sink Valley Wash	T40S, R5W, S5, 6, 7 8, & 18	Yes	Yes	No	Yes
16	Broad Hollow	T39S, R5W, S33 T40S, R5W, S5	Yes	Yes	No	No
17	Unnamed tributary to Sink Valley Wash	T40S, R5W, S4, 8 & 9	Yes	Yes	No	No
18	lower Swapp Hollow	T39S, R5W, S28	Yes	No		
19	Lower Robinson Creek	T39S, R5W, S16 & 21	Yes	No		
20	Kanab Creek	T39S, R5W, S18; T39S, R6W, S24, 25, 35 & 36	Yes	Yes	Yes	Yes
21	Alton Amphitheater Area (Kanab Creek and tributaries)	T39S, R5W, S7 & 18; T39S, R6W, S1, 11, 12 & 13	Yes	Yes	Yes	Yes
22	Unnamed tributary to Kanab Creek	T39S, R6W, S13 & 24	Yes	Yes	No	No
23	Fourmile Hollow	T40S, R6W, S4	Yes	No		
24	Broad Hollow	T40S, R6W, S10	Yes	No		
25	Dry Wash	T40S, R6W, S5	Yes	No		
26	Johnson Wash and tributaries	T42S, R5W	No			
27	Coal Hollow	T39S, R6W, S26 & 27	Yes	No		
28	Frankie Hollow	T39S, R6W, S34; T40S, R6W, S2 & 3	Yes	No		
29	Oak Canyon	T40S, R5W, S12	Yes	No	No	No
30	Adams Wash	T40S, R4W, S18 & 19	Yes	Yes	No	No

[a] Refer to Exhibit 4.5-1 for geographic extent

[b] Only those areas currently subirrigated or flood irrigated are subject to the prohibition to mining (SMC 785.19 [c

[c] Based on typical agricultural practices of local ranchers and/or available baseline stream flow and theoretical fl

[d] Geographic extent of identified AVF not determined (Division 1985)

[e] Refer to Exhibit 4.5-2

[f] Per Division's ICR (Division 1985) with the exception of No. 30-Adams Wash

ailability			PROBABLE AVF	
able ils	Suitable Water Quality	Water Available for Additional Flood Irrigation[c]	Present	Geographic Extent
			No	
			No	
es	Yes	No	Yes	Currently irrigated acreage on USLD[e]
es	Yes	No	Yes	Currently irrigated acreage on USLD[e]
			No	
			No	
			No	
			No	
			No	
			No	
			No	
			No	
			No	
es	Yes	No	No	
			No	
			No	
			No	
			No	
			No	
es	Yes	No	No	
			No	
			No	
			No	
			No	
es	Yes	No	Yes	Currently irrigated acreage on USLD[e]
es	Yes	No	Yes	Currently irrigated acreage on USLD[e]
			No	
			No	
			No	
			No	
			No	
			No	
			No	
			No	
			No	

l)
flow data

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ALTON COAL PROJECT

Summary Table of Alluvial Valley Floor Investigations

Camp Dresser & McKee Inc.

CDM

DRAWN BY	DATE	SCALE	EXHIBIT NO.
APPROVED BY		DRG. NO.	4.5-10